The Brown Street Ashfield Skew Brick Arch Underbridge

The basic facts of bricks

The most basic fact to be realised about un-reinforced masonry structures is that they are fundamentally just piles of stones or man-man units, which we call bricks or blocks, which stay in place and perform useful functions because the designers and builders have placed them in ways so that the joints between them do not come apart or slide. In general, the mortar which is placed between the units is merely to take up minor irregularities in the quarrying or manufacture. This ensures that forces between blocks or bricks are not concentrated at accidentally protruding bumps as this might overload that point and crack the unit.

In many situations overly strong mortar is no virtue at all. A structure like a house is much more likely to remain presentable with soft mortar. When the foundations move as they inevitably do, or bricks grow with age, it is better that the movement be dissipated through the masonry IN THE JOINTS, where it will not be noticed or may be re-pointed, rather than THROUGH THE BRICKS which can rarely be satisfactorily repaired, especially if all the movement is concentrated at a few large cracks. The softness of mortar is obvious from the facility with which old houses can be demolished and the bricks cleaned for re-use. Even major engineering structures such as chimneys are often recycled as useful bricks.

Most engineering structures such as arched bridges have harder mortar than the typical Victorian house which used lime mortar, but still there is a sense in which the mortar's job is merely to stop the bricks rattling. In particular, any tendency for one course of bricks to slide along the adjacent one could over time and millions of load cycles lead to deterioration and failure of the structure. The best way to transmit a force from one course of bricks to the next is square across the joint between them.

In a brick arch underbridge where the road or waterway below the railway crosses at right angles, the courses of bricks in the arch are laid parallel to that road or waterway and therefore square across the railway. The obviously large compressive force in the brick rings, brought about by the weight of the bricks, the filling above to create a level track-bed and the weight of the trains, is passed from course to course and to the rigid rock abutments square across each joint.

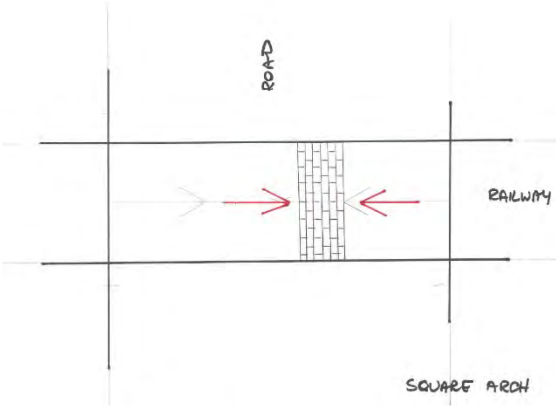


Figure 1 In a simple square arch the thrust in the arch is transmitted square across the brick courses.

The bridge works well as we know from experience and long history.

Skew bridges

Sometimes the road and the railway do not cross at right angles. In former times when road speeds were low the "S" bend to force a right-angle crossing – there are several on the 1919 Picton-Mittagong deviation as just one example – was not a problem, but in modern times such constructions are death traps and never built.

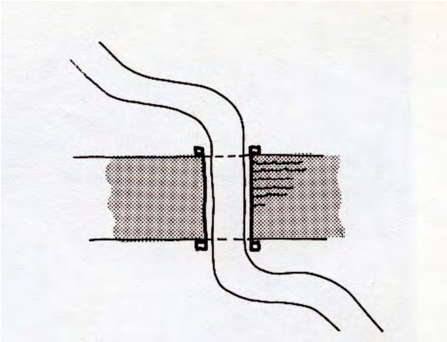


Figure 2 The 2 'S' bend approach produces the shortest and cheapest bridge, but a very dangerous traffic situation.

Even in much earlier times skew bridges were built. A skew bridge does not cross an obstacle at right angles. There are some 'easy' ways around the problem, apart from the 'S' bend solution. If the bridge carrying the upper utility is made of longer span the lower route slips under unobstructed.

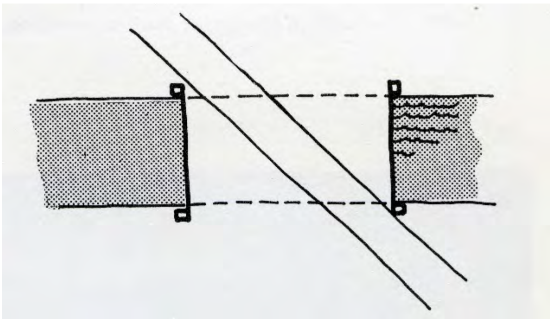


Figure 3 A longer bridge allows straight approaches, but is longer, perhaps to the point that the available technology is challenged, or the cost of the work is greatly increased.

However, there is a cost for the longer bridge and the extra length may challenge the technology available. At Old Canterbury Road, Lewisham, the Local and Suburban Line underbridges are skew metal bridges, but the Main Line Bridge is just a longer square bridge.

Alternatively, the bridge may be made only of sufficient span for the lower service, but made longer along its axis so that the upper service passes somewhat diagonally across it. The cost of this is obviously the excessive length of the bridge, but also the 'useless' pieces of bridge which carry no load and encroach on neighbouring land.

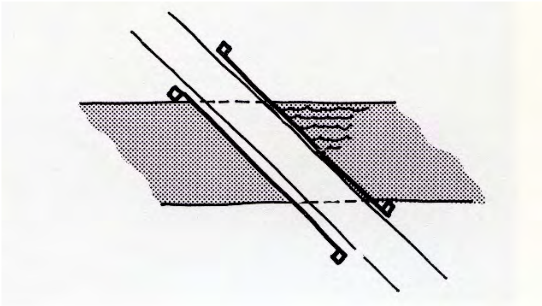


Figure 4 A wider lower bridge allows the two routes to follow straight courses, but is more expensive and encroaches on space away from the alignment of the upper service route.

At Thirlmere Way, Picton, a brick arch pierces a high embankment, not at right angles.

Figure 5 Thirlmere Way, Picton. The crossing of the railway and the road is skewed; the length of the brick arch (along the road) is more than the width of two tracks, but space is not an issue in a rural situation. The asymmetrical wing walls emphasise that the crossing is not square.

The vault of the bridge is a very conventional square arch, but it is longer than it needs to be to support the rail tracks. That is not a problem in a rural area where land is not overly scarce. Since the arch supports an embankment which supports the tracks, its length is reduced with wing walls and because of the skew these are far from symmetrical and must have been a challenge to build in an open field before the embankment rose. Bystanders must have wondered if the bricklayers knew what they were doing.

How to lay the bricks in a skew arch.

At Ashfield, Brown Street crosses below the Main Suburban Line at a considerable angle. The option of building a square-bridge-too-long, would have encroached excessively onto land which the Railways did not own.

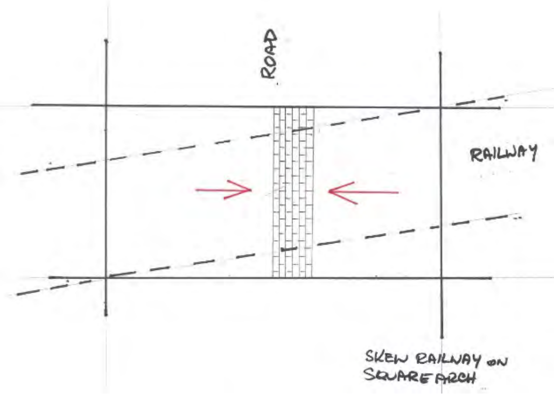


Figure 6 The Picton solution makes the brick arch project beyond the railway alignment.

The 1892 plans have a specific note to ensure that all the work stayed on Railway land, which must have been just wide enough for the five tracks required.

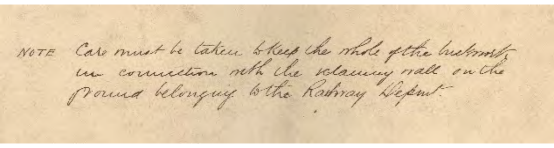

NOTE Care must be taken to keep the whole of the brickwork in connection with the retaining wall on the ground belonging to the Railway Depart.

Figure 7 A note on the original plans for the arch makes it clear that encroachment on land that they did not own was an issue for the Railways.

The design of the work was for a two-track bridge and a three-track bridge. Because of the alignment as the tracks converged after the station, not only are the two bridges skew to Brown Street, they are not parallel to each other – they are skewed at different angles. Building two square arches, both projecting beyond the minimum track alignment would have wasted space which was not available. The two bridges had to be skewed.

Figure 8 The different angle of skew for the 3-track and the 2-track brick arches is apparent in the original plans.

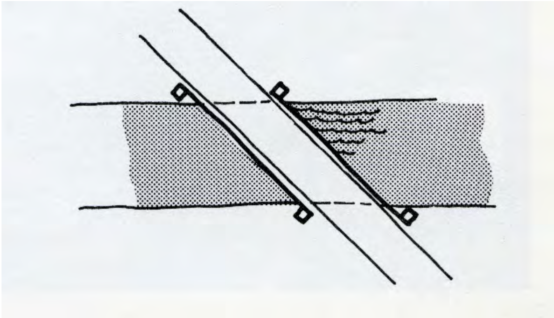


Figure 9 A skew bridge.

The first solution which might be imagined is to have notionally built a square arch and then sliced off (conceptually) a wedge at either end to leave a skew arch.

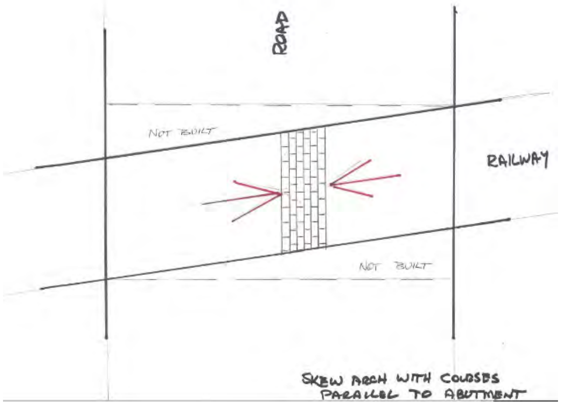


Figure 10 A skewed brick arch with the brick courses laid parallel to the abutments means that the thrust in the arch crosses the brick courses at an angle. This results in a tendency for the courses to slip along each other.

This would leave parts of the arch with nothing to push against. The force through the arch from its own weight and the trains would be parallel to the track and thus crossing each brick joint in the arch at an angle. The force in the unbalanced parts might find its way across to other parts through the brick bond – that is the fact that successive layers of brick are laid with whole bricks over the joints in the course below – but who could know how this would work, and what would crack as very non-uniform stress made its way through the mass of brickwork.

The proper solution comes from laying the brick courses at right angles to the alignment

of the bridge and therefore the force in the arch.

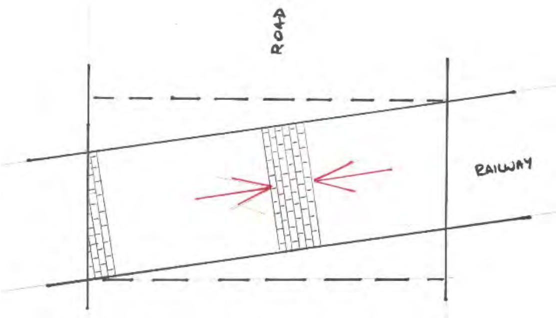


Figure 11 Laying the courses of bricks square across the arch allows the thrust on the arch to cross the bed joints at right angles but means that the courses meet the abutment at an angle.

It does mean that the courses are not level, not flat, though they are plane. Overwhelming obvious on-site inspection is the fact that they do not meet the abutments at anything like parallel.

Figure 12 The axis of Brown Street is defined by the fluorescent lights and the conduit which carries power to them. Their alignment is clearly not parallel to the brick courses. the sandstone abutment is straight and level, but the brick courses of the arch meet it an angle. Note how rainwater, seeking the steepest path down the arch moves towards the centre of the rail alignment as it descends.

The bridge as it is built

Figure 13 Each course of the brick arch ends where it 'runs into' the stone abutment blocks.

Figure 14 The large sandstone abutments have a carefully prepared, serrated top to marry up with the brick courses.

Figure 15 The stepped upper surface of the large sandstone abutment blocks.

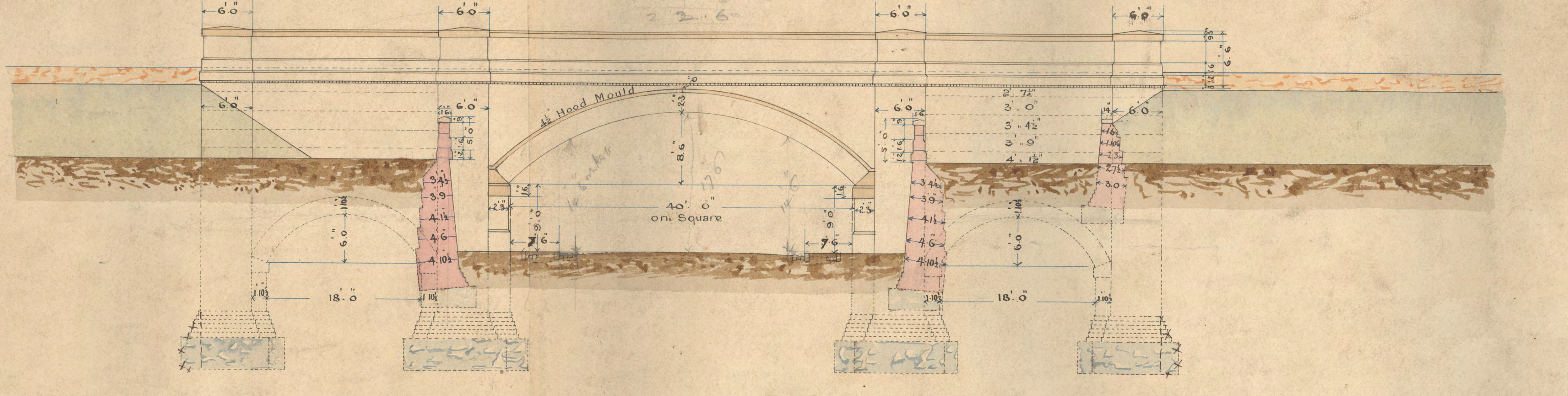
The large sandstone blocks of the skewback are serrated as each course of the arch ring disappears to nothing. Remember that these stones were dressed and placed before a

single brick was laid in the arch. Working from both sides would they meet in the middle? It is not as hard as it might be imagined. A millimetre widening or tightening of the mortar joints can make up or lose a large amount over enough courses.

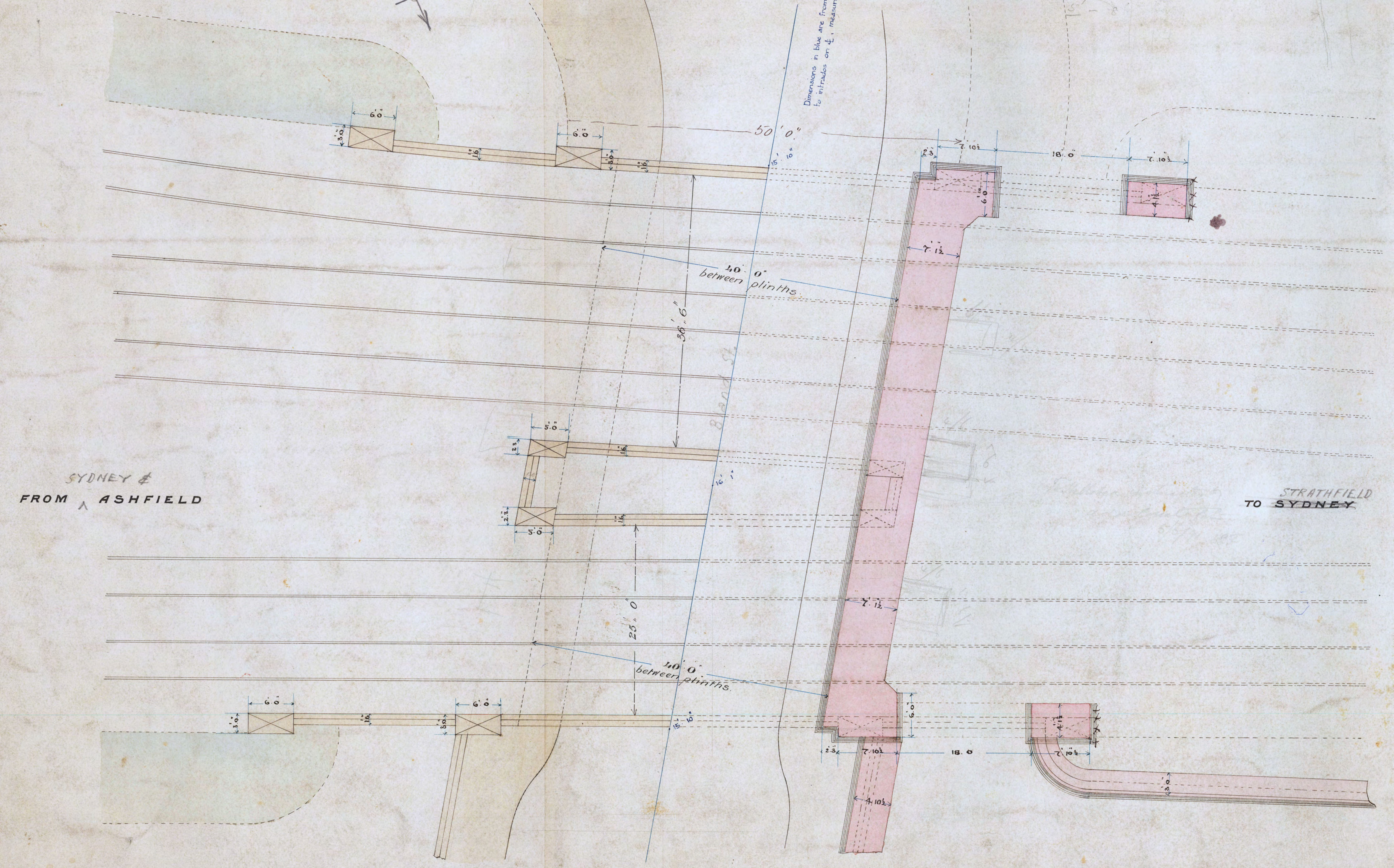
There are many two-track brick arch underbridges on the NSW Railways. Such bridges carrying more than two tracks are rare. The Wollongong Road underbridge on the Illawarra Line at Arncliffe carries four tracks. Ashfield carries three. The bridge at Oatley station once carried a siding as well as the main lines, but it is actually two double-track brick arches separated by a space in which the station stairs are located. The four-track Illawarra Main Line at Victoria Street, Erskineville is carried on a brick arch. It is believed that this is actually two abutting two-track bridges built successively. The fact that it is heavily plated with steel sheets makes assessment difficult.

The original plans.

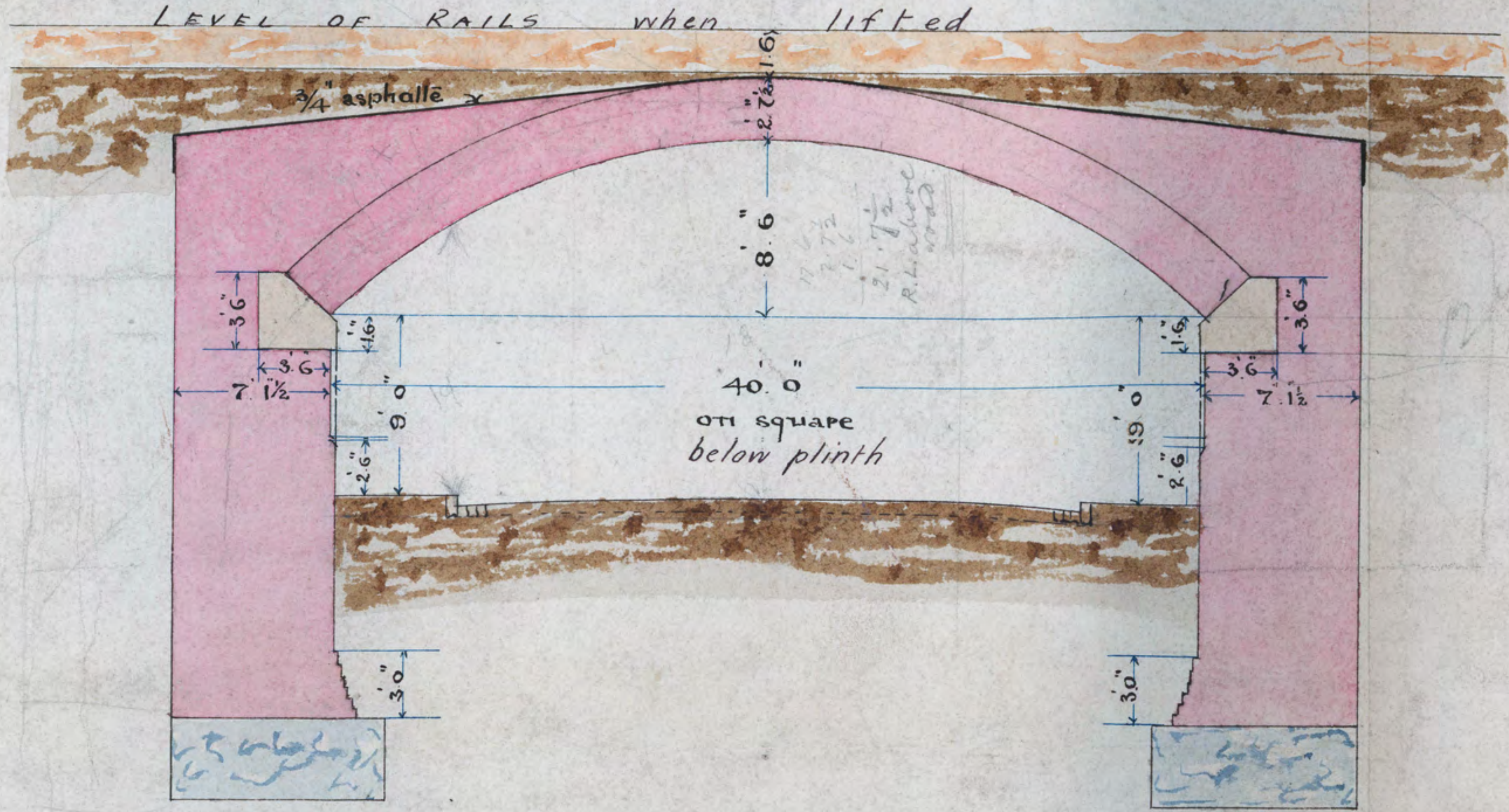
To modern eyes the plans are insufficient to build such an intricate structure. In another age only the basic facts were drawn and the 'man on the spot' was left to work out the details. The arches under the wing walls, which might suggest a pedestrian subway or culvert behind the abutments are in fact just a foundation device. Rather than carrying the whole wall down to a good foundation only isolated piers are taken down, joined by a deeply buried arch and the gravity brick retaining wingwall built above.



ELEVATION


50' 0"
40' 0" between plinths
36' 6"
25' 0"
40' 0" between plinths
7' 10½"
18' 0"
7' 1½"
SYDNEY &
FROM ASHFIELD
STRATHFIELD
TO SYDNEY

PLAN



SECTION THRO' ARCH